Electrochemical Synthesis of Architecture-Controlled Mesostructures

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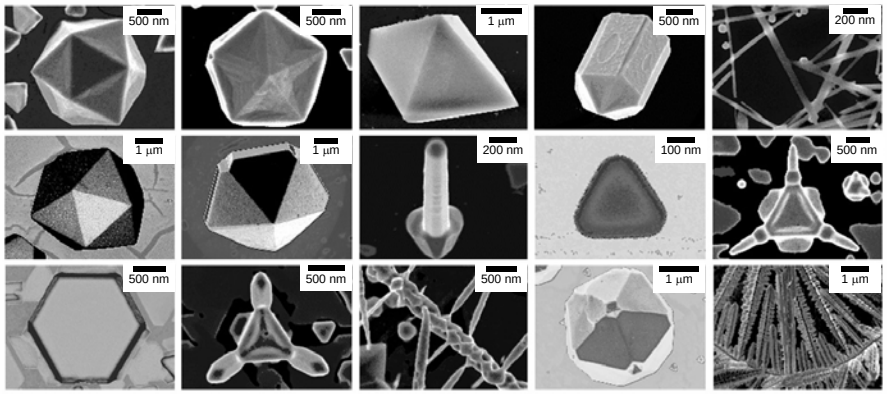
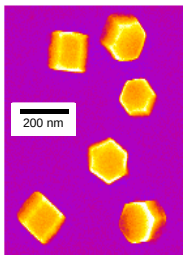
Motivation

- New synthesis techniques for self-assembling meso & nanostructures
- Controlled size and shape of three-dimensional structures
- Metallic, magnetic and superconducting crystals
- Exploration of new physical phenomena in 3D confined structures
- Study the effect of shape on nanocatalysts

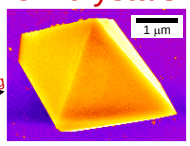
Pb meso-crystals

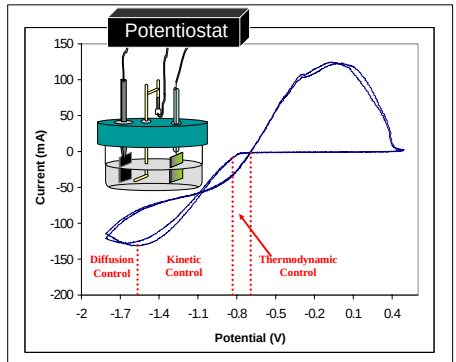


Cobalt



3D crystals





We are systematically exploring a method for electrodeposition, which accentuates the effects of ion migration and exploits fine differences within the thermo-dynamic, kinetic and diffusive regimes. The boric acid supporting electrolyte is the key. Boric acid, with a pK_a of 9, buffers the solution, but barely dissociates into ions. Low ionic strength enhances precursor migration to the growing crystals.

New Phenomena to be Explored

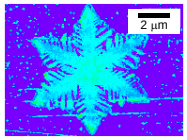
- Nucleation of superconductivity in meso-3D structures
- Novel vortex shapes, organized structures & transitions
- Tailor band structures by size & shape
- Electrochemical Atomic Layer Epitaxy semiconductor nanowires
- Metallic nanowire based sensors

Vortex distribution/splitting

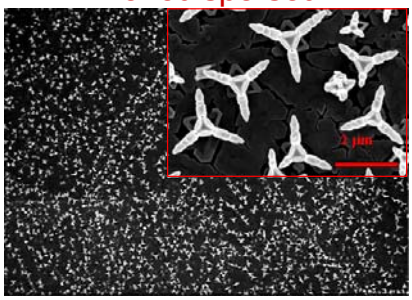
Supercurrent pathway

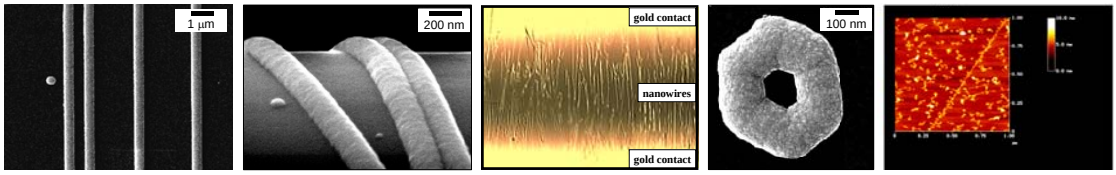
ZnS wires

2D fractal-like



Monodispersed

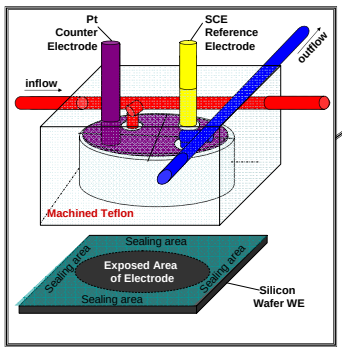




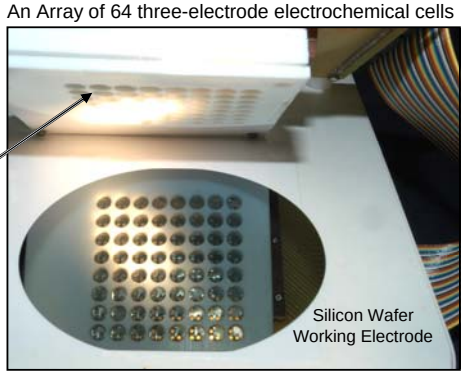
Combinatorial Electrochemistry

Controlled materials composition at the nanoscale:

- Hybrids of superconductor and magnets
- Optimized binary/ternary alloys for catalysts
- Underpotential deposited monolayer dopants
- Layered GMR superlattices by AC deposition
- Nanoscale Josephson junctions via frozen electrolyte



An Array of 64 three-electrode electrochemical cells



Nanochemistry at high speeds:

- Compact, automated synthesis and analysis
- Conquering phase space: temperature, voltage, pH, concentration, additives, etc…
- Computer control for high throughput, rapid feedback, reliability and reproducibility

"Tuning the Architecture of Mesostructures by Electrodeposition" **Xiao, Z. L *et. al.* J AM. CHEM. SOC. 126 (8): 2316-7**

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